MARE COMPONENTS IN MARE-HIGHLAND LUNAR METEORITE REGOLITH BRECCIAS: IMPLICATIONS VIS-À-VIS SOURCE-CRATER PAIRING

PAUL H. WARREN and TOMOKO ARAI, Institute of Geophysics, UCLA, Los Angeles, CA 90095-1567, USA (current addresses), and Mineralogical Institute, University of Tokyo, Hongo, Tokyo 113, Japan

Lunar meteorites can provide important constraints on the nature of the Moon's crust, especially the regolith that constitutes its outer few meters, and also on the process of transfer of material between large solar system bodies. A similar process probably supplies martian meteorites. For both these objectives, it is vitally important to assess the probability for pairing among the samples, especially in the sense of pairing through a common source location, and cratering event, on the Moon. The most direct constraints on pairing are the launch ages, i.e., the sum of the 4π plus terrestrial cosmic-ray exposure (CRE) ages. However, for most lunar meteorites the transit from Moon to Earth probably takes $<10^5$ years [1], and CRE measurements can scarcely resolve differences among such young ages. Thus, unfortunately CRE data can only eliminate the possibility of pairing for a fraction of all possible combinations of lunar meteorites.

CRE data [2,3] indicate that of the six lunar meteorites that contain large mare components, one (Calcalong Creek) has an apparently unique launch age. Two (Y-793169 and As-881757) both have launch age ~ 10^6 yr; these two "YA" meteorites also show strong geochemical similarity [4], and thus are probably source-crater paired. The other three (EET87521, Y-793274 and QUE94281) all have CRE launch age $<10^5$ yr, a finding consistent with (although only *faintly* suggestive of) source-crater pairing. This trio, especially Y-793274 and QUE94281, are petrologically remarkably similar [5-8]. All are breccias, with large mare basalt components that are dominantly VLT, and uncommonly slowly cooled (or annealed) by mare standards, if development of coarse pyroxene exsolution is any indication [5,6]. Y-793274 and QUE94281 are also similar texturally (immature regolith breccias) and contain a dominantly low-KREEP variety of highland debris.

Clinching evidence for source-crater pairing of Y-793274 and QUE94281 comes from our analyses of low-Ti mare glass spherules (probably of pyroclastic origin [9]) from the matrices of these breccias. Our data for these spherules (Fig. 1; the data set excludes a few similar but largely crystalline and, thus, heterogeneous spherules, and one oddball that has a vastly lower MgO content: 6.4 wt%, along with 1.4 wt% TiO_2) show a compositional bimodality, based mainly on TiO_2, although a similar bimodality is evident in Al_2O_3 content for glasses with MgO ~ 13 wt%. Note that the same two distinctive compositional trends dominate the glasses in both breccias. We consider the overall similarity between these two meteorites strong enough to warrant designating them collectively as "YQ."

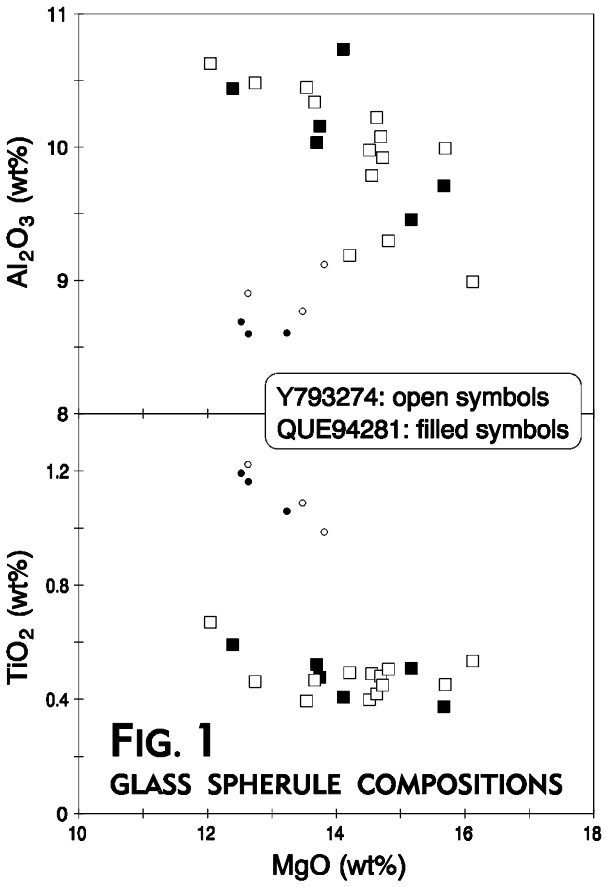


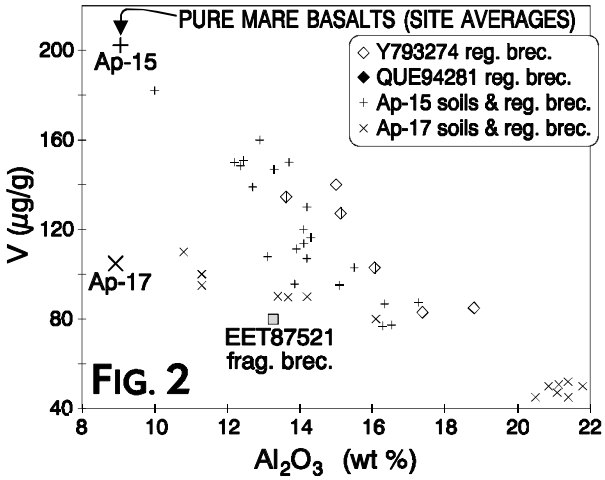
FIG. 1
GLASS SPHERULE COMPOSITIONS

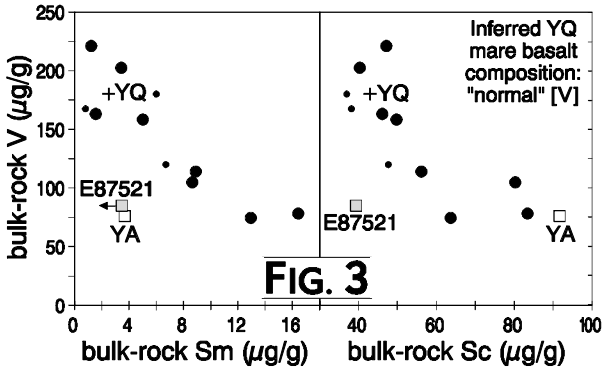
The relationship between the YQ meteorites and EET87521 is less clear. EET87521 is a far less thoroughly blended fragmental breccia that lacks spherules. It has only a tiny highland component, which appears KREEP-rich compared to the YQ highland matter [10]. To constrain the issue of pairing among the YQ and EET87521

meteorites, we have utilized an extrapolation technique to constraint the composition of the dominant mare component in YQ, which may be compared with the virtually pure-mare composition of EET87521. The extrapolations exploit the heterogeneity of the YQ regolith breccias, mainly using plots of Al_2O_3, which derives largely from highland debris, vs. elements that tend to be equally or more concentrated in mare basalts than in highland material. Analogous plots for regolith samples from mixed mare-highland Apollo sites (Apollo 17, 15, and to a lesser extent 12) typically show trends that extrapolate towards the composition of the average local mare basalt, especially for mafic-compatible elements such as Mg, Sc, Ti, V, Cr and Co. The most important example is V (Fig. 2), although in this case the trends are relatively ill-defined, as the data base for lunar V is relatively poor, in terms of both quantity and, in several sets of many papers, quality. For V in YQ, besides data from our own lab, Fig. 2 uses two Y-793274 analyses from Fukuoka [11].

Extrapolation of the YQ trend on Fig. 2 toward a plausible Al_2O_3, content (~ 11 wt%, based on analogy with Apollo 17 and Luna 24 VLT basalts) indicates that the V content of the YQ mare basalt is probably far higher than that of EET87521 [10]. We adopt V = 180 µg/g as a conservatively low estimate. Similar (in most cases more clearly defined) extrapolations indicate MgO = roughly 7 wt%, Sc ~ 43 µg/g, TiO_2 ≈ 0.8 wt%, Cr ~ 2500 µg/g, Co ~ 45 µg/g, and Sm (taken as a representative incompatible element) ~ 2.5 µg/g. For most of these elements, the extrapolation trend is consistent with pairing with EET87521. But the extrapolated YQ contents of Cr and especially V appear significantly higher than their EET87521 counterparts (≈ 1800 µg/g and 80 µg/g, respectively [10]). The V content of the YQ mare basalt appears unexceptional for a basalt with its overall composition (Fig. 3; shown for comparison are site-averaged mare basalt compositions for Apollo and Luna sites, plus the compositions of three well-determined pyroclastic glass types). The V content of EET87521, however, seems unusually low for a VLT, low-Sm, low-Sc mare basalt.

Our findings reinforce the likelihood that Y-793274 and QUE94281 are source-crater paired, but suggest that EET87521 is most likely the product of a separate launch event.





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